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# Effect of Date of Sowing on Growth, Yield and Quality of Beetroot (*Beta vulgaris* L.) Varieties at Kapilakot, Sindhuli, Nepal

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## Abstract

A field experiment was carried out in the Horticulture farm of the College of Natural Resource Management, Kapilakot, Sindhuli, Nepal, from October 2020 to February 2021 to determine the optimum date of seed sowing on growth, yield, and quality of beetroot (*Beta vulgaris* L.) varieties. The experiment was laid out for nine treatment combinations from two factors in a randomized complete block design with four replications. The first factors comprised the three sowing dates (October 15, November 1 and November 15) while the second factors included three beetroot varieties (Action, Madhur and Ruby Red). The results revealed that sowing date and varieties significantly influenced the growth, yield, and quality parameters of beetroot. Among the date of sowing, plant height (43.04 cm), number of leaves per plant (14.24), leaf length (40.7), root length (10.66 cm), root diameter (64. 48 mm), individual root weight (192.72 gm), shoot weight per plant (133.69 gm), economic yield (32.11 t $ha^{-1}$), biological yield (52.7 t $ha^{-1}$), root dry matter (10.66%), and leaf dry matter (9.16 %) were significantly highest in October 15 date of sowing. Similarly, canopy diameter (39.97) and leaf breadth (11.4 cm) were statistically higher on the November 1 date of sowing. Likewise, among the varieties, plant height (43.12 cm), leaf length (40.7 cm), root length (10.66 cm), root diameter (63.83 mm), individual root weight (190.37 gm), shoot weight per plant (128.4 gm), economic yield (31.72 t $ha^{-1}$), biological yield (53.12 t $ha^{-1}$), and root dry matter (10.66%) were significantly higher in Action variety. Likewise, a total soluble solid was found to be maximum (12.04$^0$ Brix) on October 15 sowing date and the pH of beetroot juice was recorded as highest (6.62) on November 1 sowing date. Therefore, based on the results of the experiment, October 15 sowing and variety Action was better for optimum yield and quality beetroot production in Sindhuli, Nepal.
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## Keywords

Beetroot; Sowing date; Yield; Quality

## Introduction

Beetroot (*Beta vulgaris* L.), also called garden beet, table beet or red beet, is one of the major root vegetables belonging to the family Chenopodiaceae along with spinach, palak, swiss-chard, parsley and celery. It has a chromosome number of 2n=18 (Sri Vidhya and Radhai, 2018). It is a fast-growing, cool-season biennial root vegetable crop grown as an annual for its fleshy swollen roots. The ancestors of modern cultivated beets are thought to be the Sea Beets (*Beta vulgaris* subsp. *moritima,* which prospered along the coast of the Mediterranean Sea (Akan, Tuna Gunes and Erkan, 2021). Today, all the different cultivated forms of *Beta vulgaris* subsp. *vulgaris* are distinguished at the variety level such as beetroot or table beet is *Beta vulgaris* var. *conditiva,* swiss-chard is *Beta vulgaris var. cicla,* fodder beet is *Beta vulgaris var. alba,* and sugar beet is *Beta vulgaris var. altissima* (Brickell *et al.,* 2016*).*

Beetroot produces green tops and a swollen tap root during the first growing season, and nutrients stored in the tap root are used to produce flowers and seeds in the second season. Leaves are often ovate, dark green or reddish, and the rosette leaves develop in a close spiral with the oldest one on the outside. The basal leaves have long petioles. The upper leaves are smaller; their blades are rhombic to narrow lanceolate (Misra and Shrivastava, 2022). The inflorescence is a botanically large spike. It is consumed in the form of salad, vegetables and processed products. Roots of the beet are a good source of nutrients. It contains protein (1.7 g), carbohydrates (8.8 g), minerals, particularly calcium (18 mg), phosphorus (55 mg), vitamin C (10 mg) and 87.70% of water per 100 g of fresh weight (Sumrah, Bakhsh and Ahmad, 2003). Purple-crimson color of beetroot is due to the pigment betacyanin, which helps to suppress the development of cancer and possesses antioxidant properties (Rey *et al*., 2005; Szopinska and Gaweda (2013).

Though, beetroot has many nutritional and health benefits, this underutilized and neglected vegetable is relatively new for Nepalese farmers. There are limited numbers of vegetables that dominate the whole country, and the use of hybrid varieties of vegetables is increasing year after year in Nepal (Rawal *et al*., 2017). Beetroot crop can be successfully raised by sowing the seeds in October to November in Sindhuli conditions. But no systematic work has been carried out so far to find out the best sowing date to reap higher root yields of beetroot (Gupta, 2020). Major constraints in the production of beetroots are basically poor agricultural practices, including the appropriate date of seed sowing and selection of the high-yielding varieties for different agro-climatic regions of Nepal. Time of sowing and selection of cultivar play a crucial role in the production of superior quality roots, but the research work done on these aspects is very few in Nepal. Availability of suitable high-yielding cultivars and determination of optimum seed sowing may help the farmers to achieve more returns per unit area. The suitable agro-climatic condition of Sindhuli is quite favorable, and there is tremendous potential for taking up commercial cultivation of this crop but standardization of horticultural practices has not been done so far under local agro-climatic conditions for its profitable cultivation.

Appropriate agronomic practices like suitable planting date and varieties have a profound effect on the development and outcome of the crop. Hence, there is a need to find out a suitable cultivar with optimum time of sowing in order to reap higher yields

of beetroot. The present research is therefore aimed at finding out the optimum sowing date on growth, yield, and quality of beetroot varieties at Kapilakot, Sindhuli, Nepal.

## Materials and Methods

### *Location of the research site*

The experiment was conducted in field conditions at Agriculture and Forestry University, College of Natural Resource Management, Kapilakot, Sindhuli, located at $27^0$ 15' north latitude and $85^0$44' east longitude with an elevation of 290 masl.

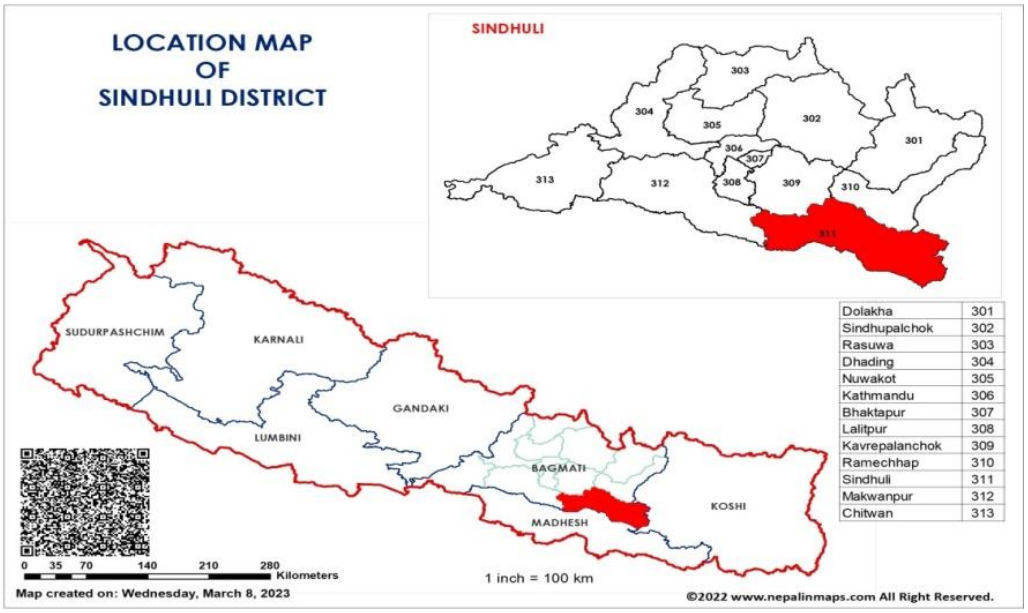


Figure 1: Map of the Nepal showing research site

### *Agro-climatic condition of the research site*

The meteorological data of the experiment site during the cropping period was collected. The weekly average data on different weather parameters, i.e. maximum temperature, minimum temperature, relative humidity and total rainfall during the growing season of beetroot are presented in figure 2. The maximum temperature ranged from 22.6°C ($2^{nd}$ week of January 2021) to 31.2°C ($3^{rd}$ week of October 2020). The minimum temperature ranged from 9 °C ($1^{st}$ week of January 2021 to 17.35°C ($4^{th}$ week of October 2020). Likewise, the average relative humidity of the cropping period was 91.54 %. Rainfall (12.4 mm) and (13.2 mm) recorded during the $4^{th}$ week of December 2020 and the $3^{rd}$ week of January 2021, respectively.

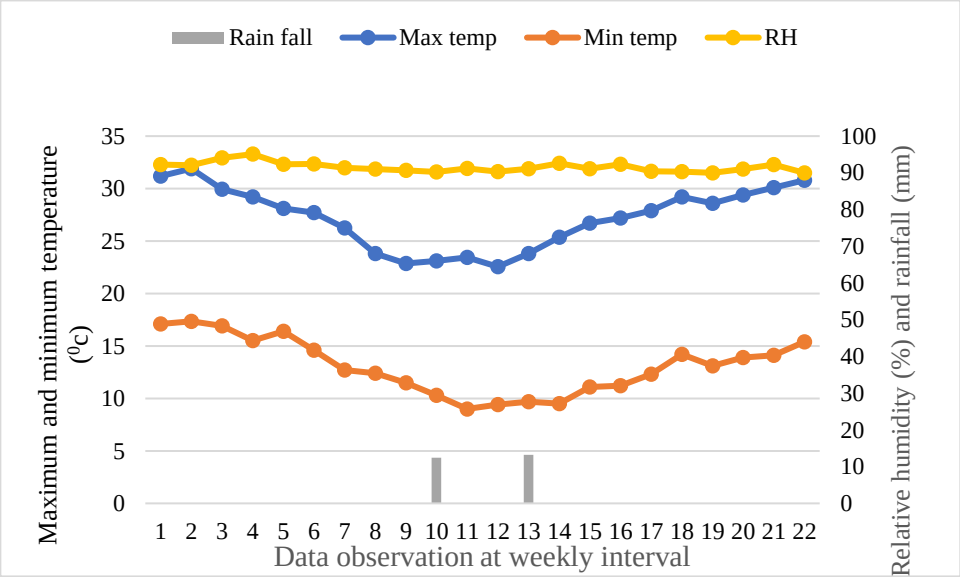


Figure 2: Maximum temperature, minimum temperature, relative humidity, and rainfall during the experimental period (October 2020 to February 2021)

***Soil properties***

The soil samples were collected from each experimental plot for chemical analysis before sowing the seed. The air-dried and filtered soil was taken to the Soil and Fertilizer Testing Laboratory of Bagmati Provincet, Hetauda, Makwanpur District, Nepal, to measure the total nitrogen by the Macro-Kjeldahl method, available phosphorus by Olsen's bicarbonate, and available potash by the ammonium acetate method. Organic matter was determined by the Walkely and Black method, pH by the Beckman Glass Electrode pH, and soil texture by the hydrometer method. The soil of the experimental field was acidic (pH 5.9), containing medium organic matter (3.8%), medium total nitrogen (0.15%), medium available phosphorus (47.56 kg $ha^{-1}$) and high available potassium (155.16 kg $ha^{-1}$).

***Experimental details***

The experiment was conducted between October 2020 to February 2021 at the experimental field of the College of Natural Resource Management, Kapilakot, Sindhuli, Nepal. The experiment design was a Randomized Complete Block Design. Two factors, viz. three sowing dates and three varieties of beetroot were used in the experiment.

***Treatment details***

Table 1: Details of the treatment

| *Sowing date: (Factor A)* | *Beetroot Varieties: (Factor B)* |
|---|---|
| October 15 ($D_1$) | Action (Hybrid) ($V_1$) |
| November 1 ($D_2$) | Madhur (Open pollinated) ($V_2$) |
| November 15 ($D_3$) | Ruby Red (Open pollinated) ($V_3$) |

Table 2: Treatment combinations used in the experiment

| *S.N.* | *Treatment combination* | *Treatment details* |
|---|---|---|
| $T_1$ | $D_1V_1$ | October 15 with a variety of Action |
| $T_2$ | $D_1V_2$ | October 15 with a variety of Madhur |
| $T_3$ | $D_1V_3$ | October 15 with a variety of Ruby Red |
| $T_4$ | $D_2V_1$ | November 1 with a variety of Action |
| $T_5$ | $D_2V_2$ | November 1 with a variety of Madhur |
| $T_6$ | $D_2V_3$ | November 1 with variety Ruby Red |
| $T_7$ | $D_3V_1$ | November 15 with a variety of Action |
| $T_8$ | $D_3V_2$ | November 15 with a variety of Madhur |
| $T_9$ | $D_3V_3$ | November 15 with variety Ruby Red |

***Details of field operations***

Each plot was supplied with a recommended dose of fertilizer, i.e., 20 t $ha^{-1}$ FYM and 120:80:40 kg NPK $ha^{-1}$. There were a total of 36 plots, each of which was 1.8 m × 1.8 m in size. The seeds were sown on three different dates, i.e. October 15, November 1, and November 15, 2020, with a distance of 45 x 10 cm. All the intercultural operations, including thinning, weeding, spraying, and irrigation, were done regularly. Growth parameters such as plant height (cm), no of leaves per plant, leaf length (cm), leaf breadth (cm), canopy diameter (cm), root length (cm), root diameter (mm), root weight (gm), leaf weight (gm), economic yield (t $ha^{-1}$), biological yield (t $ha^{-1}$), root dry matter (%), leaf dry matter (%), TSS ($^0$Brix), and pH were recorded after harvest.

***Data analysis***

The collected data were compiled and subjected to analysis of variance using the Microsoft Excel. R- Studio version 4.2.3 was used for the analysis of variance of all parameters. Mean comparison was done at a 5% level of significance using Duncan's Multiple Range Test (DMRT). Microsoft Excel was used for the construction of graphs and tables.

## Results

***Growth characteristics***

*Plant height*

The plant height of beetroot differed significantly at DMRT analysis ($p<0.05$) in different dates of seed sowing and varieties at final harvest (Table 3). Plant height was significantly higher on the 1$^{st}$ date of sowing, i.e. October 15, which was statistically similar to the 2$^{nd}$ date of sowing, i.e. November 1 (42.28 cm) and the lowest plant height was found (39.68 cm) in the sowing at November 15. Likewise, statistically higher plant height was obtained in variety Action (43.12 cm), which was statistically at par with the Madhur (41.86 cm), and the lowest plant height was recorded in Ruby Red (40.02 cm). The interaction effect of date of sowing and varieties did not show any significant effect on plant height at final harvest.

*Number of leaves per plant*

The number of leaves per plant of beetroot differed significantly at DMRT analysis, $p<0.05$, in different dates of sowing and varieties at final harvest (Table 3). The number of leaves per plant was significantly higher (14.24) on the October 15 date of sowing, which was statistically similar to the November 1 sowing (13.78), and the lowest number of leaves was found (12.24) in the sowing at November 15. Likewise, a statistically higher number of leaves per plant were obtained in the variety Madhur (14.06 cm), which was statistically at par with the Action (13.4), and the lowest number of leaves was recorded in Ruby Red (12.8). The interaction effect of date of sowing and varieties did not show any significant effect on the number of leaves per plant at final harvest.

*Leaf length*

At the final harvest, the beetroot leaf length varied considerably depending on the variety and the date of seed sowing (Table 3). The October 15 sowing date had the lowest leaf length (37.41 cm), while the October 15 sowing date had the much longer leaf length (40.7 cm), which was statistically at par to the November 1 planting (40.11 cm). Similarly, variety Action had a statistically longer leaf length (40.70 cm), which was statistically similar to Madhur (39.78 cm), whereas Ruby Red had the shortest leaf length (37.74 cm). The interaction effect of date of sowing and varieties did not show any significant effect on the leaf length of the plant at final harvest.

*Breadth of the longest leaf*

The breadth of the longest leaf of beetroot differed significantly in different dates of seed sowing and varieties at final harvest (Table 3). Leaf breadth was significantly higher (11.40 cm) on November 1 date of sowing, which was statistically at par with the October 15 sowing (11.08 cm), and the lowest leaf breadth (9.58 cm) was found in the sowing at November 15. However, varieties of beetroot did not showed significant effect on the breadth of the longest leaf. Likewise, the interaction effect of date of sowing and varieties did not show any significant effect on the breadth of the longest leaf at final harvest.

*Canopy diameter*

Canopy diameter was significantly higher (39.97 cm) on the November 1 date of sowing, and the lowest canopy diameter (33.86 cm) was found in the sowing on November 15. However, varieties of beetroot did not show a significant effect on the canopy diameter of the plant. Likewise, the interaction effect of date of sowing and varieties did not show any significant effect on the canopy diameter of the plant at final harvest.

***Yield and yield attributing characteristics***

*Root length, root diameter, root weight plant$^{-1}$, and shoot weight$^{-1}$*

The root length of beetroot differed significantly at DMRT analysis, $p<0.05$, in different dates of sowing at final harvest (Table 4). Root length was significantly higher (10.66

cm) in October 15 sowing, which was statistically at par with November 1 sowing (10.3cm), and the lowest root length (9.05 cm) was found in November 15. However, varieties of beetroot did not show a significant effect on the root length of the plant. Likewise, the interaction effect of date of sowing and varieties did not show any significant effect on root length of the plant at final harvest.

Table 3: Effect of date of sowing and varieties on plant height, no of leaves plant$^{-1}$, leaf length, leaf breadth, and canopy diameter of beetroot at Kapilakot, Sindhuli, Nepal (2020-2021)

| *Treatments* | *At the final harvest* | | | | |
|---|---|---|---|---|---|
| | *Plant height (cm)* | *No of leaves plant$^{-1}$* | *Leaf length (cm)* | *Leaf breadth cm)* | *Canopy diameter (cm)* |
| Date of sowing (Factor A) | | | | | |
| October 15 | 43.04$^{a}$ | 14.24$^{a}$ | 40.70$^{a}$ | 11.08$^{a}$ | 37.92$^{b}$ |
| November 1 | 42.28$^{a}$ | 13.78$^{a}$ | 40.11$^{a}$ | 11.40$^{a}$ | 39.97$^{a}$ |
| November 15 | 39.68$^{b}$ | 12.24$^{b}$ | 37.41$^{b}$ | 9.58$^{b}$ | 33.86$^{c}$ |
| SEM (±) | 0.34 | 0.55 | 1.2 | 0.77 | 0.96 |
| $LSD_{0.05}$ | 1.73** | 0.93*** | 2.03** | 1.3* | 1.62*** |
| Varieties (Factor B) | | | | | |
| Action | 43.12$^{a}$ | 13.40$^{ab}$ | 40.70$^{a}$ | 10.47 | 36.81 |
| Madhur | 41.86$^{a}$ | 14.06$^{a}$ | 39.78$^{a}$ | 11.05 | 38.32 |
| Ruby Red | 40.02$^{b}$ | 12.81$^{b}$ | 37.74$^{b}$ | 10.54 | 36.62 |
| SEM (±) | 0.34 | 0.55 | 1.2 | 0.77 | 0.96 |
| $LSD_{0.05}$ | 1.73** | 0.93* | 2.03* | ns | ns |
| Grand mean | 41.67 | 13.42 | 39.41 | 10.69 | 37.25 |
| CV, % | 4.94 | 8.62 | 6.13 | 14.49 | 5.18 |

Note: Means with the same letter within a column do not differ significantly at p = 0.05 by DMRT. *Significant at 5% (p<0.05), **significant at 1% (p<0.01), ***significant at 0.1% (p<0.001), ns-non significant, SEM(±)-Standard error of mean, LSD - Least significant difference, and CV-Coefficient of variance

At the final harvest, there were significant differences in the root diameter of beetroot at DMRT analysis p<0.05 in different seed sowing dates (Table 4). The November 1 sowing saw a significantly larger root diameter (59.45 mm), which was statistically at par to the October 15 sowing (58.36 mm). Additionally, the seed that was sown on November 15 had the smallest root diameter (55.32 mm). Similar to this, variety Action had a statistically higher root diameter (63.83 mm), while Ruby Red had the lowest root diameter (59.39 mm). The interaction between the varieties and the date of sowing, however, had no discernible effect on the plant's root diameter.

The root weight per plant of beetroot differed significantly in different dates of sowing and varieties (Table 4). Root weight was significantly higher (192.72 gm) in the October 15 sowing and the lowest (165.59 gm) was found in the sowing at November 15 sowing. Similarly, Action variety produced significantly higher root weight per plant (190.37 gm), which was statistically similar to Madhur (177.76 gm) and the lowest root weight

was recorded in variety Ruby Red (165.59 gm). However, the interaction effect of date of sowing and varieties did not show any significant effect on the root weight of the plant at final harvest.

The shoot weight per plant of beetroot differed significantly at different dates of seed sowing (Table 4). Shoot weight per plant was significantly higher (133.69 g) in the October 15 sowing and the lowest was found in the seed sowing at November 15 sowing. However, the effect of varieties on shoot weight per plant was found to be non-significant.

Table 4: Effect of date of sowing and varieties on root length, root diameter, root weight plant$^{-1}$, and shoot weight$^{-1}$ of beetroot at Kapilakot, Sindhuli, Nepal (2020-2021)

| *Treatments* | *Root length (cm)* | *Root diameter (mm)* | *Root weight plant$^{-1}$ (gm)* | *Shoot weight plant$^{-1}$ (gm)* |
|---|---|---|---|---|
| Date of sowing (Factor A) | | | | |
| October 15 | 10.66$^{a}$ | 64.48$^{a}$ | 192.72$^{a}$ | 133.69$^{a}$ |
| November 1 | 10.30$^{a}$ | 61.23$^{b}$ | 174.81$^{b}$ | 123.56$^{ab}$ |
| November 15 | 9.05$^{b}$ | 58.10$^{c}$ | 165.59$^{b}$ | 116.68$^{b}$ |
| LSD | 0.79*** | 3.01*** | 14.36** | 10.46** |
| SEM (±) | 0.47 | 1.78 | 4.92 | 3.58 |
| Varieties (Factor B) | | | | |
| Action | 9.96 | 63.83$^{a}$ | 190.37$^{a}$ | 128.40 |
| Madhur | 10.46 | 60.58$^{b}$ | 177.76$^{ab}$ | 124.58 |
| Ruby Red | 9.60 | 59.39$^{b}$ | 164.98$^{b}$ | 120.95 |
| $LSD_{0.05}$ | ns | 3.01* | 14.36** | ns |
| SEM (±) | 0.47 | 1.78 | 4.92 | 3.58 |
| Grand mean | 10.00 | 61.27 | 177.7 | 124.64 |
| CV, % | 9.48 | 5.83 | 9.59 | 9.96 |

Note: Means with the same letter within a column do not differ significantly at p = 0.05 by DMRT. *Significant at 5% (p<0.05), **significant at 1% (p<0.01), *** significant at 0.1%% % (p<0.001), ns-non significant, SEM(±)-Standard error of mean, LSD - Least significant difference, and CV-Coefficient of variance

*Yield*

The economic and biological yields of beetroot exhibited significant differences according to DMRT analysis (p<0.05) based on the timing of seed sowing (Table 5). The highest economic yield was recorded (32.11 t ha$^{-1}$) from the October 15 sowing which was statistically similar to the yield (29.13 t ha$^{-1}$) from the November 1 sowing. In contrast, the lowest economic yield was observed for the November 15 sowing at 27.6 t ha$^{-1}$. Among the varieties, Action produced a higher economic yield of 31.76 t ha$^{-1}$, which was statistically at par to that of Madhur (29.64 t ha$^{-1}$), while Ruby Red yielded the lowest economic yield (27.49 t ha$^{-1}$). However, the interaction between sowing dates and varieties did not demonstrate any significant impact on economic yield.

The October 15 sowing produced a statistically higher biological yield (52.70 t $ha^{-1}$) than the November 1 sowing (51.41 t $ha^{-1}$). And the seed sown on November 15 produced the lowest economic yield (47.04 t $ha^{-1}$). Similarly, Action variety produced significantly higher biological yield (53.12 t $ha^{-1}$), which was statistically similar to Madhur (50.38 t $ha^{-1}$), and the lowest biological yield was produced by Ruby Red (47.65 t $ha^{-1}$). The biological yield of the plant, however, was not significantly impacted by the interaction between the varieties and the date of sowing (Table 6).

Table 5: Effect of date of sowing and varieties on economic yield and biological yield of beetroot at Kapilakot, Sindhuli, Nepal (2020-2021)

| *Treatments* | *Economic yield (t $ha^{-1}$)* | *Biological yield (t $ha^{-1}$)* |
|---|---|---|
| Date of sowing (Factor A) | | |
| October 15 | 32.11[a] | 52.70[a] |
| November 1 | 29.13[b] | 51.41[a] |
| November 15 | 27.60[b] | 47.04[b] |
| $LSD_{0.05}$ | 2.23** | 3.31** |
| SEM (±) | 0.82 | 1.04 |
| Varieties (Factor B) | | |
| Action | 31.72[a] | 53.12[a] |
| Madhur | 29.64[ab] | 50.38[ab] |
| Ruby Red | 27.49[b] | 47.65[b] |
| $LSD_{0.05}$ | 2.23** | 3.31** |
| SEM (±) | 0.82 | 1.04 |
| Grand mean | 29.61 | 50.38 |
| CV, % | 9.59 | 7.37 |

Note: Means with the same letter within a column do not differ significantly at p = 0.05 by DMRT. *Significant at 5% ($p<0.05$), **significant at 1% ($p<0.01$), ns-non significant, SEM(±)-Standard error of mean, LSD - Least significant difference, and CV-Coefficient of variance

Table 6: Interaction effect of date of sowing and varieties on economic yield and biological yield of beetroot at Kapilakot, Sindhuli, Nepal (2020-2021)

| *Treatments* | *Economic yield (t $ha^{-1}$)* | *Biological yield (t $ha^{-1}$)* |
|---|---|---|
| Date of sowing x Varieties | | |
| October 15 x Action | 32.17 | 54.31 |
| October 15 x Madhur | 28.80 | 51.72 |
| October 15 x Ruby Red | 26.42 | 48.21 |
| November 1 x Action | 34.26 | 55.12 |
| November 1 x Madhur | 32.50 | 53.14 |
| November 1 x Ruby Red | 29.57 | 49.85 |
| November 15 x Action | 28.72 | 49.93 |
| November 15 x Madhur | 27.61 | 46.29 |
| November 15 x Ruby Red | 26.48 | 44.89 |
| $LSD_{0.05}$ | ns | ns |
| SEM (±) | 0.82 | 1.07 |
| Grand mean | 29.61 | 50.38 |
| CV, % | 9.59 | 7.37 |

Note: Means with the same letter within a column do not differ significantly at p = 0.05 by DMRT, ns-non significant, SEM (±)-Standard error of mean, LSD - Least significant difference, and CV-Coefficient of variance

*Root dry matter and shoot dry matter percentage*

The root dry matter percentage and shoot dry matter percentage of beetroot differed significantly at DMRT analysis $p<0.05$ in different dates of seed sowing and varieties (Table 7). Root dry matter was significantly higher (10.66%) in October 15 sowing, which was statistically at par with November 1 sowing (10.38 %), and the lowest root dry matter (9.3%) was found in November 15 sowing. Similarly, among varieties, Action had a significantly higher percentage of dry matter in root (10.66%), which was statistically similar to Madhur (10.02 %) and Ruby Red had the lowest percentage of dry matter (9.65%) in root. However, the interaction effect of date of sowing and varieties did not show any significant effect on root dry matter percentage. The leaf dry matter was significantly higher (9.16%) in October 15 sowing, which was statistically at par with November 1 sowing (8.99%), and the lowest leaf dry matter (7.98%) was found in November 15 sowing. However, varieties did not show any significant effect on leaf dry matter percentage (Table 7).

Table 7: Effect of date of sowing and varieties on root dry matter and leaf dry matter of beetroot at Kapilakot, Sindhuli, Nepal (2020-2021)

| *Treatments* | *Root dry matter (%)* | *Leaf dry matter (%)* |
|---|---|---|
| Date of sowing (Factor A) | | |
| October 15 | 10.66[a] | 9.16[a] |
| November 1 | 10.38[a] | 8.99[a] |
| November 15 | 9.30[b] | 7.98[b] |
| $LSD_{0.05}$ | 0.68** | 0.74** |
| SEM (±) | 0.23 | 0.25 |
| Varieties (Factor B) | | |
| Action | 10.66[a] | 8.60 |
| Madhur | 10.02[ab] | 8.92 |
| Ruby Red | 9.65[b] | 8.61 |
| $LSD_{0.05}$ | 0.68* | ns |
| SEM (±) | 0.23 | 0.25 |
| Grand mean | 10.11 | 8.71 |
| CV, % | 8.08 | 10.15 |

Note: Means with the same letter within a column do not differ significantly at p = 0.05 by DMRT. *Significant at 5% ($p<0.05$), **significant at 1% ($p<0.01$), ns-non significant, SEM (±)-Standard error of mean, LSD - Least significant difference, and CV-Coefficient of variance

***Total soluble solids (TSS) and pH***

The TSS of beetroot juice differed significantly at DMRT analysis $p<0.05$ in different dates of seed sowing (Table 8). TSS was significantly higher (12.04 $^0$Brix) on October 15 sowing and the lowest TSS was recorded (10.55 $^0$Brix) from November 15 sowing. However, varieties did not produce any significant effect on the TSS of the root.

Likewise, the interaction effect of date of sowing and varieties did not show any significant effect on root dry matter percentage. The pH of beetroot juice was significantly higher (6.62) in November 1 sowing and the lowest pH was recorded in October 15 sowing. However, varieties did not show any significant effect on the pH of the root.

Table 8: Effect of date of sowing and varieties on total soluble solids and pH of beetroot at Kapilakot, Sindhuli, Nepal (2020-2021)

| *Treatments* | *Total soluble solids ($^0$Brix)* | *pH* |
|---|---|---|
| Days of sowing (Factor A) | | |
| October 15 | 12.04[a] | 6.36[b] |
| November 1 | 11.09[b] | 6.62[a] |
| November 15 | 10.55[b] | 6.37[b] |
| $LSD_{0.05}$ | 0.78** | 0.2* |
| SEM (±) | 0.26 | 0.07 |
| Varieties (Factor B) | | |
| Action | 11.39 | 6.44 |
| Madhur | 11.22 | 6.47 |
| Ruby Red | 11.06 | 6.44 |
| $LSD_{0.05}$ | ns | ns |
| SEM (±) | 0.26 | 0.07 |
| Grand mean | 11.23 | 6.45 |
| CV, % | 8.32 | 3.75 |

Note: Means with the same letter within a column do not differ significantly at p = 0.05 by DMRT. *Significant at 5% (p<0.05), **significant at 1% (p<0.01), ns-non significant, SEM(±)-Standard error of mean, LSD - Least significant difference, and CV-Coefficient of variance

## Discussion

### *Effect of sowing date and varieties on growth parameters*

The maximum plant height (43.04 cm), greater number of leaves per plant (14.24), and longer leaf length (40.7 cm) were found in the October 15 date of sowing, which was followed by the November 15 date of sowing. Leaf breadth was observed to be maximum (11.4 cm) on November 1 date of seed sowing, and canopy diameter is statistically significant and recorded maximum (39.97 cm) on October 15 of sowing. Most of the vegetative parameters showed significantly better performance in the October 15 sowing. This might be because decrease in temperature and due to less availability of sunlight during the sowing of seed on November 1 and November 15. Better performance of the plant of October 15 sowing might be due to favorable growing conditions, which might have resulted in luxuriant growth of these vegetative characters in the Sindhuli district of Nepal. The results are similar by the findings of Rinaldi and Vonella (2006) in sugarbeet, Lavanya *et al*. (2017) in radish; Parajuli and Dhital (2023) in radish.

The variation in plant height, leaf number, leaf length, leaf breadth, and canopy diameter in diverse genotypes might be due to their differences in genetic makeup. Arya (2020) found that significant response among beetroot varieties on vegetative characters such as plant height, leaf number, and canopy diameter.

***Effect of sowing date and varieties on yield and quality parameters***

The root length (10.66 cm), root diameter (64.48 mm), shoot weight (133.69 gm) of beetroot was found statistically significant in October 15 date of sowing and lowest root length (9.05 cm), root diameter (58.1 mm), and shoot weight (116.68 gm) was found in the November 15 sowing date. And the lowest root diameter (58.1 mm) and root weight per plant (165.59 g) were found on November 15 date of seed sowing. The greater root length and diameter of beetroot during early sowing date might be due to favorable climatic conditions, as there is less sunlight and extreme cold temperature during the November 15 sowing date. The increase in root diameter might be due to more leaf number and canopy, which can be attributed to the process of metabolic activity of the plant resulting in translocation of photosynthates from the source of formation to the developing sink (root). The efficient utilization of these photosynthates might have led to a better root diameter, root length, which leads to an increase in root weight per plant. The results are similar with findings those obtained by Rupareliya *et al*. (2025) in beetroot; Bauskar (2015) in radish; Murthy (2014) in carrot, and Lavanya *et al*. (2017) in radish

Most of the yield and yield attributing characters were significantly superior in the variety Action, which was followed by the Madhur variety (Tables 4 and 5). The root diameter and root weight were significantly higher (63.83 mm and 190.37 g) in the variety Action, while the lowest was in Ruby Red. These differences could be attributed to the genetic structure of the evaluated beetroot varieties. The greater root diameter in the variety Action might have resulted in the highest fresh root yield. The varietal differences in the beetroot root length, root diameter and shoot weight are in line with those obtained by Sapkota *et al*., (2021) in beetroot; Gupta (2020) in beetroot. This result is also in harmony with findings obtained by Martin (1983) in radish; Shalaby, Osman and Abdel-Fatah (2011) in sugarbeet.

The maximum economic yield (32.11 t $ha^{-1}$) was recorded on October 15 date of seed sowing, and statistically higher biological yield (52.7 t $ha^{-1}$) was produced on October 15 date of sowing, and the lowest economic yield and biological yield was recorded on November 15 date of seed sowing. Similarly, the variety Action produced greater root yield (31.72 t $ha^{-1}$) and biological yield (53.12t $ha^{-1}$), which is statistically similar to Madhur. This might be due to better growth and yield attributing parameters such as number of leaves, longer leaves, wider leaves, and greater canopy diameter, greater root diameter, and root weight and ultimately greater economic and biological yield. Furthermore, the difference in the yield among varieties might be due to the interaction effect of genetic makeup and environment, as various varieties of the same species grown even in the same environment often yield differently. Similar results were obtained by Jilani and Ghaffoor (2003) in onion; Patel, Sharma and Verma (2016) in beetroot; Feller and Fink (2004) in beetroot, Öztürk *et al*. (2008) in sugarbeet; and Lauferet *et al*. (2016) in sugarbeet.

Root dry matter and leaf dry matter were significantly higher (10.66 % and 9.16 %) on the October 15 date of sowing, and the lowest was found in November 15 sowing. Similarly, among varieties, Action had a significantly higher percentage of dry matter in the root (10.66 %), and the lowest was found in Ruby Red. Similar results of varietal differences with respect to root and leaf dry matter percentage were reported by Takács-Hájos and Vargas-Rubóczk (2022) in beetroot; Kahsay, Belew and Abay (2013) in onion. Total soluble solids were significantly higher (12.04 $^0$Brix) in Oct 15 and the lowest TSS (10.55 $^0$Brix) was recorded from November 15. This result is supported by the findings of Gobarah *et al*. (2019) in sugarbeet as well as Parajuli and Dhital (2023) in carrot. .

## Conclusion

Hence, from the present investigation, it can be concluded that early, i.e. October 15, date of seed sowing performed better for most of the growth, yield, and quality parameters of beetroot. October 15 sowing produced a higher number of leaves per plant, root length, root diameter, economic yield and biological yield than other dates of sowing. Similarly, Root dry matter and TSS of the root were also found superior in early sowing dates. Among varieties, Action performed better than other tested varieties of beetroot. It produced a greater yield of marketable size with good quality. Therefore, a variety of actions with the October 15 date of seed sowing is considered appropriate for the optimum yield and quality beetroot production in the Sindhuli district of Nepal. However, further research efforts should be done using these measures in a number of other varieties and sowing dates in different agro-climatic locations of the country for further validation.

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## Authors' Declarations and Essential Ethical Compliances

*Authors' Contributions (in accordance with ICMJE criteria for authorship)*

| *Contribution* | *Author 1* | *Author 2* | *Author 3* | *Author 4* | *Author 5* |
|---|---|---|---|---|---|
| Conceived and designed the research or analysis | Yes | Yes | Yes | Yes | Yes |
| Collected the data | Yes | No | No | No | No |
| Contributed to data analysis & interpretation | Yes | Yes | Yes | Yes | Yes |
| Wrote the article/paper | Yes | Yes | No | No | No |
| Critical revision of the article/paper | No | Yes | Yes | Yes | Yes |
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